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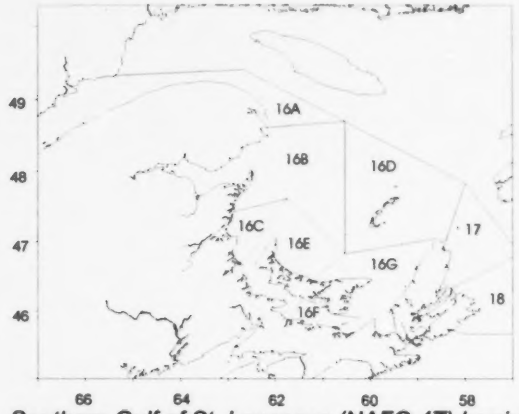
Science Advisory Report 2005/070

SPAWNING STOCK BIOMASS REFERENCE POINTS FOR SOUTHERN GULF OF ST. LAWRENCE HERRING



Southern Gulf of St. Lawrence (NAFO 4T) herring management areas.

Context

There is a need to develop conservation reference points consistent with a precautionary approach. These reference points would be used in conjunction with the $F_{0.1}$ removal reference to develop a harvest strategy to ensure the conservation of the spring and fall spawning components of 4T Herring in the southern Gulf of St. Lawrence (4T). These populations are assessed separately, using Virtual Population Analysis (VPA) as the main analytical tool. While the fall component continues to be healthy, the spring component has been declining for several years and is now estimated to be below long-term average levels.

SUMMARY

- Spawning stock biomass reference points compliant with the Precautionary Approach were derived for the spring and fall components of 4T herring.
- Limit reference points (LRP) for the spring and fall components were 22,000 t and 51,000 t respectively.
- Interim values for the upper stock reference (USR) for the spring and fall components were 54,000 t and 172,000 t respectively.
- The removal rate reference has previously been set at F0.1, which corresponds to 0.35 for the spring component and 0.32 for the fall component.

DESCRIPTION OF THE ISSUE

Herring in the southern Gulf of St. Lawrence are comprised of a spring and a fall spawning component. The most recent assessments of these stock components (LeBlanc et al. 2005) indicated that the biomass of the fall component was generally healthy and above average during 1978-2005. On the other hand, the spring component had declined since the mid-1990s with the 2005 estimate below average over the same period. Given the declining abundance of the spring component and consistent with the application of the Precautionary Approach, it was recommended at the March 2005 Regional Advisory Process meeting that biomass reference points be derived for these two components. These reference points would be used in conjunction with the removal reference to develop a harvest strategy. In the case of southern Gulf of St. Lawrence herring, the removal rate reference has previously been set at $F_{0.1}$, which corresponds to 0.35 for the spring component and 0.32 for the fall component.

A harvest strategy compliant with the Precautionary Approach would include the adoption of two biomass reference points, a Limit Reference Point (LRP) and an Upper Stock Reference (USR), which would divide stock abundance into three zones: critical, cautious and healthy (Fig. 1). The LRP is the stock level below which productivity is considered sufficiently impaired to cause serious harm but is above the level where the risk of extinction becomes a concern. The USR is defined as the stock level below which the removal rate is reduced from the reference level.

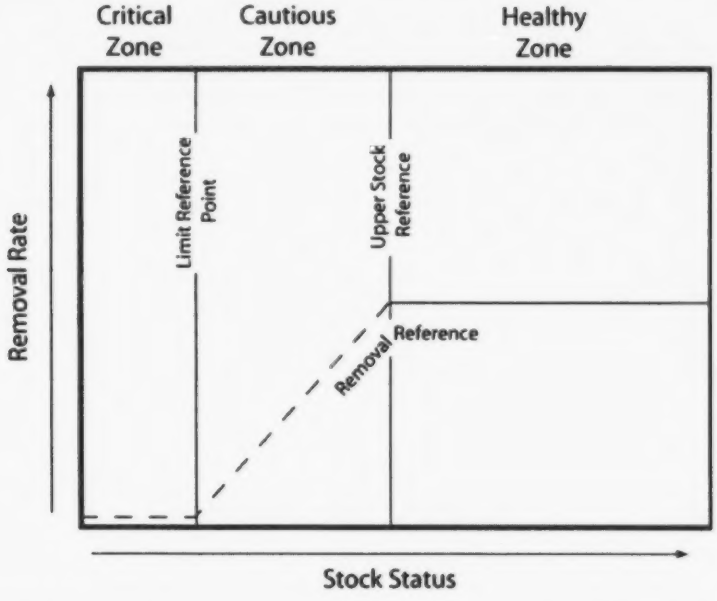


Figure 1. Illustration of a fisheries management framework consistent with the Precautionary approach.

When the spawning stock biomass (SSB) is above the USR, the exploitation rate is set at the removal reference level. If the SSB declines below the USR, a harvesting strategy compliant with the Precautionary Approach would progressively reduce the exploitation rate to promote stock growth to above the USR. Finally, if the SSB declines below the LRP, then removals from the stock should be kept to the lowest level possible.

Spawning stock biomass values below the USR represent undesirable stock levels. In some fisheries, target reference points are also used to maintain the stock at a level to achieve

desired objectives, the latter taking into account a combination of biological and socio-economic considerations. These target reference points are never below the USR value (Rice and Rivard 2002) and are not addressed in this document.

ASSESSMENT OF ISSUE

Information Sources

Data used in the analyses included the spawning stock biomass and recruitment estimates, exploitation rate estimates, weights at age, and partial recruitment profiles from the most recent assessment of the stock (LeBlanc et al. 2005). Natural mortality was assumed to be 0.2.

Reference Points

Three LRP definitions, as described for other marine species (Rivard and Rice 2002), were considered: 1) $B_{recover}$ corresponding to the lowest historical SSB from which the stock readily recovered, 2) BH_{50} or RK_{50} which is the SSB which produces 50% of the maximum recruitment based on either a Beverton-Holt (BH_{50}) or Ricker (RK_{50}) stock recruitment relationship, and 3) $SB_{50/90}$ corresponding to the SSB which can produce median recruitment under favourable conditions.

Expected spawning stock biomass assuming average recruitment (age 2) and the removal rate reference were calculated using spawner per recruit analyses based on stock characteristics data (vectors of mean weight at age, natural mortality, partial recruitment) for both the spring and fall components. The USR was not directly defined but would be located somewhere between the LRP and the expected SSB at the removal rate reference.

The lowest historical SSB from which the stock was able to recover ($B_{recover}$) for the spring and fall components were 11,500 and 37,000 t, respectively. The numbers of recruits produced from these low SSB levels were exceptionally high (highest points in Fig. 2) and may have been a compensatory response to low abundance but additionally could have resulted from favourable biological and environmental conditions prevalent during that period. As such, the high recruitment per SSB ratios observed and the recovery of the stock may not occur at similar low levels of biomass in the future if conditions are less favourable.

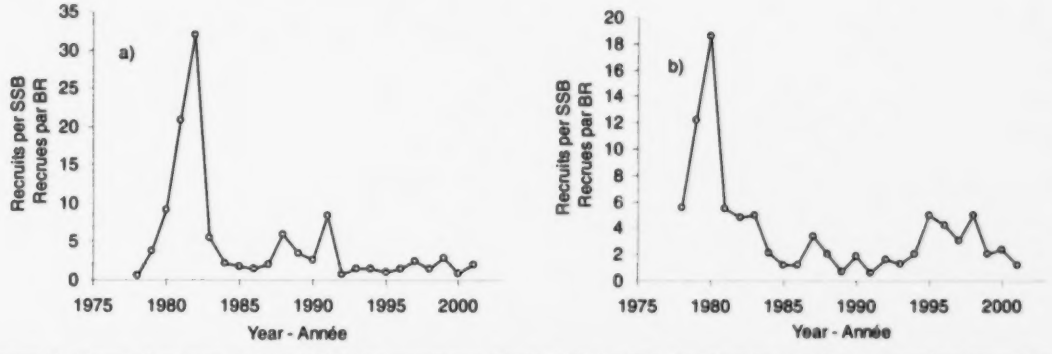


Figure 2. Recruit at age 2 per SSB for southern Gulf (NAFO 4T) herring (a) spring spawning component; b) fall spawning component), 1978-2001.

High recruitment to SSB ratios were observed for several years in the late 1970s. Spawning stock biomass also increased as fishing rates were reduced. It was considered that the average of the four lowest values of biomass during that time period would represent a more cautious estimate of the LRP. This corresponds to 22,000 t for the spring component and 51,000 t for the fall component.

For both the spring and fall components, the recruitment at age 2 relative to the SSB has large variability. For the spring herring component, there is no discernible relationship between SSB and recruitment (Fig. 3). As a result of the poorly defined association between recruitment and SSB for either the Beverton-Holt or the Ricker functions, the estimation of LRPs from these stock and recruitment data was not considered appropriate.

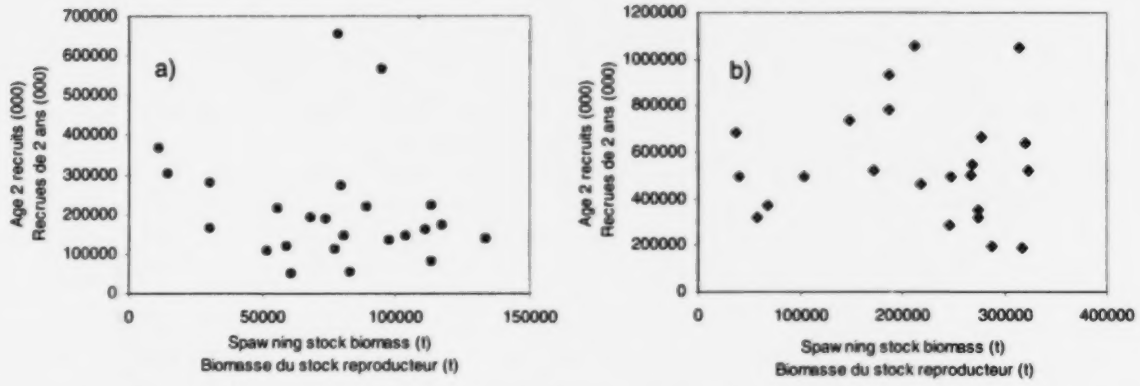


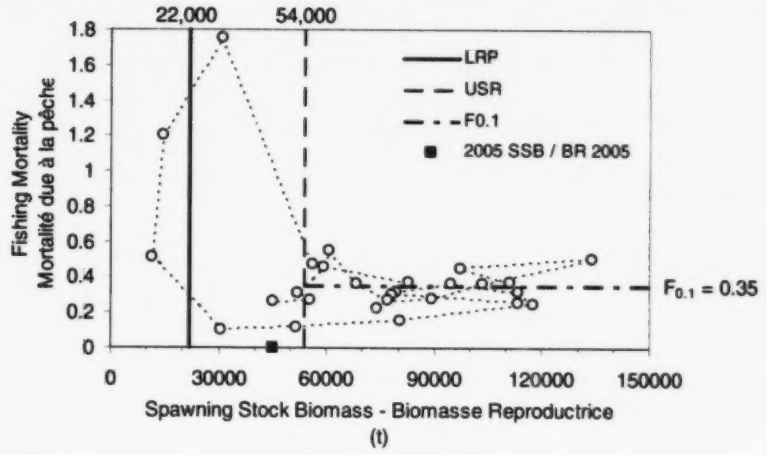
Figure 3. SSB and recruitment (age 2) for southern Gulf (NAFO 4T) herring (a) spring spawning component; b) fall spawning component), 1978-2001.

The $SB_{50/90}$ estimates for the spring and fall components were 19,500 and 90,000 t, respectively. This reference point has seldom been used in practice and its properties are not well known.

The expected SSB levels assuming average recruitment and the removal rate reference for the spring and fall components were about 54,000 t and 172,000 t, respectively. Spawning stock biomass could be expected to fluctuate around these values and thus the USRs would be set somewhere between the LRPs and these expected SSB levels.

Due to the uncertainty in the stock and recruitment dynamics of both the spring and fall components of 4T herring, it was considered appropriate to have the USR closer to the expected SSB than to the LRP. The plot of historical values of exploitation rate and SSB showed that with exception to the first 5 to 6 years of the time series, the SSB estimates for both the spring and fall components were generally above the expected SSB levels (Fig. 4). These expected SSB levels were considered to be appropriate interim values for the USR.

Spring



Fall

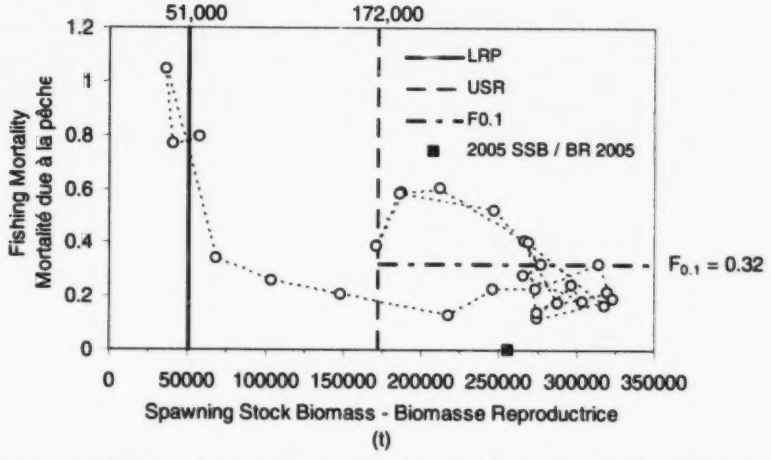


Figure 4. Estimated spawning stock biomass and fishing mortality for the spring and fall components of southern Gulf of St. Lawrence herring for 1978 to 2004 (open circles) and suggested reference points (LRP,USR and $F_{0.1}$). The 2005 estimates of spawning stock biomass are indicated (filled square).

Other Considerations

In addition to the biomass reference points, other measures may be required to ensure the conservation of herring in the southern Gulf of St. Lawrence. Spawning of herring from the spring and fall components occurs regularly in well-defined geographic areas. The current fishery allocations within each of the spawning components are based to some extent on historical catches. If herring from each component return to the same spawning areas with a high degree of fidelity, then it would be important that the distribution of the allocations be based on this consideration in order to preserve the within spawning component stock structure.

Sources of Uncertainty

There is a large amount of variability in recruitment relative to SSB for both spawning components of herring in 4T. Reference points based on dynamics described by stock and

recruitment functions were not considered appropriate at this time. There are also uncertainties on the status of the fall component given the retrospective patterns of the virtual population assessment. However, biomass estimates derived using methods to correct for the retrospective bias indicate that SSB is greater than the interim USR for this component. Analyses to further refine these reference points based on stock productivity and the delay in availability of recruitment estimates relative to rates of decline should be conducted.

CONCLUSIONS AND ADVICE

For the spring component, the limit reference point and interim upper stock reference proposed are 22,000 and 54,000 t respectively. For the fall component, the values are 51,000 and 172,000 t respectively. It is recommended that these reference points be used in the application of a Precautionary Approach framework for southern Gulf of St. Lawrence herring. These reference points should be examined periodically to determine their suitability and revised, if appropriate, given additional information on stock dynamics.

Relative to these reference points, the spawning stock biomass of the fall component is considered to be in the healthy zone in 2005. For the spring component, the spawning stock biomass in 2005 is in the cautious zone. The harvest strategy implied in the cautious zone is to reduce exploitation below the removal reference with the objective of increasing SSB. A number of harvest strategies consistent with this principle are possible. Ideally, these would be developed in consultation with stakeholders.

SOURCES OF INFORMATION

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